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The thinning of dense sapling and pole stands of ponderosa pine in such manner that maximum volume and quality growth will be encouraged is one of the most serious problems confronting foresters and lumbermen of the ponderosa-pine region. Even on the better sites existing sapling and pole stands over considerable areas are exceedingly dense, while on the poorer sites, east of the Cascade Range in Oregon and Washington, density is so extreme that in many stands there has developed a condition of growth stagnation. Meyer, in his study of the growth of selectively cut ponderosa-pine forests of the Pacific Northwest 4/, concluded that the condition of the existing sapling and pole stands is one of the most discouraging phases of the management of ponderosa pine, since growth averages only about ten percent of the normal that should be expected. He also concluded that the cut at the end of the second and subsequent cutting cycles will be imperiled if stagnation is allowed to persist.

Foresters have proposed various corrective measures. Some would attempt to thin the stands by plowing criss-crossed lanes by means of the tractor and "bulldozer", in the hope that the trees bordering these lanes will benefit through release. Others suggest thinning by the axe and saw, or by means of light power saws. The writer is of the opinion

that thinning by controlled fire should also be tried. Such the writer suggested several years ago, in an article presenting evidence that for countless centuries the ponderosa pine forests were formerly swept by periodic fires, occurring at fairly frequent intervals. 5/ He also traced the cyclic process by which density, age classes and composition were controlled by such fires, acting in conjunction with pine beetles and other agencies.

The opportunity to test the use of controlled fire in the thinning of dense sapling and pole stands first presented itself to the writer in October, 1942, when he supervised the burning of five plots, comprising approximately 240 acres in total area, on the Nartar timber unit of the Colville Indian Reservation in north-central Washington. Also, during subsequent years, many hundreds of acres of dense saplings and poles on cut-over land were burned over by creeping or slow running fires as a result of tests of spot burning of unpiled and tractor piled slash resulting from selective logging operations on the various timber sale units of the reservation. 6/

The 1942 tests were undertaken for the primary purpose of determining if volume and quality growth of ponderosa pine sapling and pole stands can be improved through thinning by controlled fire. The specific objectives of the slash burning tests were to determine (1) the economic feasibility of disposing of logging slash in the ponderosa-pine type over extensive areas by tractor piling and burning and by controlled spot burning, and (2) the resultant effects on reserve stands, including the saplings and poles. Of interest also, in both instances, were possible effects

with respect to increase or decrease of the fire hazard and effects on the ground cover and on the establishment of subsequent reproduction.

STAND CONDITIONS

Stand conditions, before burning on the test plots and before selective cutting and slash burning on the timber sale units, were characteristic of those prevailing in the greater portion of the ponderosa-pine region. The uneven-aged stand was comprised of even-aged groups of trees in various stages of maturity, with the mature and overmature age classes predominating with respect to merchantable volume. Groups of thrifty, fast growing ponderosa pine poles, antedating the last extensive wild fires of 1917 and 1920, occupied many of the large and small openings. Openings caused by attacks of the western pine beetle subsequent to these fires were largely occupied by ponderosa pine reproduction of sapling size. Many clumps of this younger reproduction were dense, though growth stagnation had not as yet developed. Scattered through these clumps were standing and windfelled remains of the pines that had been killed by beetles since the fires. Snags of Douglas fir and western larch predominated on many of the steeper north slopes. Such conditions, with respect to saplings and poles, were characteristic of the greatest portion of the area covered by the slash burning tests.

Four of the smaller test plots burned in October, 1942, included groups of saplings and poles on areas that had not been burned over by wild fires since the years 1905 and 1910. These stands were much more dense and included large clumps where a condition of growth stagnation had developed. Snags and windfalls were more numerous and other inflam-

mble debris on the ground was much heavier.

Topographic and ground cover conditions varied considerably. In the drier western portion of the reservation, on the Kaptar-Koses Mountain area, the controlled burning and slash burning tests were conducted at elevations of from 2400 to 3900 feet above sea level, on gentle to moderate slopes of rolling, round topped granite mountains. Ground cover consisted principally of pinegrass, with shrubs a minor component. In the more humid eastern portion of the reservation, in the Hall Creek area, conditions differed considerably. There the slash burning tests were conducted on broad stream valley bottoms, at elevations of from 1900 to 2100 feet, and on mountain slopes that rose steeply to 4000 feet elevation. The slopes were occupied by dense stands of various shrubs which covered a considerable portion of the ground surface under the larger trees and in the openings in mixture with the saplings and poles. Pinegrass occurred at higher elevations, but was largely displaced by cheatgrass in the valleys, probably because of prolonged grazing by cattle and horses from nearby Indian ranches.

Slash burning tests were also conducted on various portions of the San Poil valley drainage, in the central portion of the reservation, on areas of varying topography and ground cover.

THE BURNING OPERATIONS

When conducting the burning of the five plots in October, 1942, a crew of five or six men first plowed fire lines by means of a light crawler type tractor and Easter 3 disc plow. Wherever it was necessary to go through the midst of sapling or pole stands considerable swamping was in-

volved. It was also necessary to fell dangerous snags that might throw live sparks over the line. After the fire lines were completed and when conditions were favorable, the burning was conducted against the wind or down the slopes, while the plow unit was held on standby duty, ready to go if anything went wrong.

Conditions for conducting the tests were ideal. The luxuriant growth of grasses and weeds resulting from the unusually heavy precipitation of spring and early summer had thoroughly cured as a result of a two months long dry spell and this ground cover, together with the heavy needle mat under the trees, furnished abundant fuel to carry the fire along over the forest floor. At the same time the period of high fire hazard had passed and burning could be conducted with but low to moderate risk because of the steadily lengthening, frosty nights.

The first plot, roughly circular in shape and 18.4 acres in area, was burned during the late afternoon of October 6, while the sky was heavily overcast and a stiff breeze blew steadily from the southwest. After firing along the line, on the sides away from the wind, it was attempted to hurry matters a bit by setting another strip of fire farther inside. Such promptly resulted in "blow-ups" in several thick patches of saplings and poles. After that experience the fire was permitted to advance against the wind on a roughly semicircular front, while the crew confined its activities to patrol and observation and to occasional backfiring, when some tongue of the fire pushed too far ahead inside and threatened to start a "run-back" towards the fire line.

The fire could be observed at close range as it fed on the grass and

needles under the trees. Only at intervals were hot fires ignited, about snags and along windfalls. These fires were especially hot about the upturned, pitchy roots and where logs were crossed.

After the burning of plot A was completed anticipated rain storms failed to materialize, though the weather continued cloudy and conditions for the burning were ideal. Plot B was burned on a late afternoon, while the sky was heavily overcast and the air quiet. Plot C, the largest, was burned during the daytime while the sky was partially overcast and a light, variable breeze was blowing. Plot 4 was burned during a late afternoon, while the sky was partially overcast and the air quiet. Plot 5 was burned during the daytime of October 24, while a very light, misty rain was falling. The fire ran readily under the trees, where it could feed on the needle mat, but stopped at the edges of the grassy openings. It was necessary to set numerous strip fires.

The experience gained in burning these test plots helped considerably when conducting the slash burning tests during the following years. In these tests the same general technique of burning was employed. Small crews were used, abandoned logging truck roads and skid trails, supplemented, where necessary, by plowed or "bulldozed" trails, were utilized as fire lines, dangerous snags were felled and burning was conducted against the wind and down the slopes. Most of this burning was accomplished after the first light rainstorms of the fall, when the nights were frosty and the days sunny and quiet.

When burning, the men in the crews were instructed, in addition to firing the slash piles, or the unpiled tops or windrows of slash, to set

fire to every snag and windfall that could be made to burn without the expenditure of too much time and effort. By disposing of the bulk of this highly inflammable, dangerous material, when conditions for such burning were favorable, the subsequent creeping and slow running fires in the needles and grass were prevented from causing damaging "blow-ups". Actually such creeping and running fires were prevented from covering more than 50 percent of the ground surface because of the wind trails. Moderate to heavy grazing by sheep, previous to burning, was also found to prevent the fires from covering much of the ground surface.

Burning was accomplished by means of propane gas or gasoline backfiring torches. When burning progressive narrow strips across the faces of steep slopes it was found best to employ only one or two torches. When more torches were employed under such conditions it was found that some of the torch men evidenced a tendency to become impatient and to crowd the man ahead and above too closely, thus allowing the fire opportunity to sweep up the slope with terrific heat.

METHOD OF GATHERING DATA

A detailed plane table map has been made of controlled burning plot 1. On this map there have been indicated the areas of reproduction of adequate and inadequate stocking and the position of each and every tree above 6 inches D.B.H. Also there have been established 17 fifth acre circular sub-plots of 52.66 feet radius each, selected mechanically in a grid like pattern. On each sub-plot there have been selected from 6 to 29 sapling or pole "crop trees", the number varying with the density of the orig-

inal stocking and the number of suitable trees surviving. These trees, marked for future identification by means of numbered metal tags, are the ones that it is believed will survive to make the best growth and to comprise the merchantable stand that will eventually be harvested. As a check 6 unburned fifth acre circular plots were established in unburned clumps of saplings and poles in the near vicinity. Detailed measurements of the crop trees on both the burned and unburned sub-plots were made in the spring of 1943 and again in the spring of 1945.

It was originally planned to establish similar sub-plots within the other controlled burning plots and to also establish check plots in nearby unburned reproduction. A similar study of some of the dense sapling and pole patches burned over during the slash burning tests has also been contemplated. The press of other work, however, and the shortage of personnel resulting from the war have prevented such activities.

RESULTS

It is still too early for the crop tree measurements to present data of eventual growth significance. The 1943 examination did disclose that 36 of the 322 crop trees originally selected in the spring of 1943 had died during the intervening two years. The 286 trees now surviving appear healthy and it is believed that they have fully recovered and that few, if any, will die in the immediate future. With respect to release from competition, resulting from the burn, the 1945 examination disclosed that of the average of 17.9 trees originally competing with each crop tree, within a circle of 10 feet radius, 13.4, comprising 37.9 percent of the original basal area, have been eliminated.

The plane table map indicates that 7.8 acres, comprising 65.5 percent of the original sapling and pole stand of 11.9 acres, are still adequately stocked. The 4.1 acres whereon the fire thinned too severely are comprised principally of the clumps where the fire "blew-up" when it was attempted to hurry matters by setting the strip fire.

General observations of the controlled burning plots and of the hundreds of acres of saplings and poles burned over as a result of slash burning, as well as the limited data collected, indicate that thinning results are spotty. Holes were frequently made in the stands where hot fires burned about snags and along windfalls, and where big trees had been felled and the tops and limbs left unpiled. At other places, where fuel on the ground was light, the fire killed but few trees. Over the greatest portion of the areas, however, it is believed that the burning resulted in the leaving of an adequate number of well spaced crop trees and that these trees have been released through elimination of many competing trees.

It is apparent that the fires discriminated against smaller trees of the intermediate and suppressed sapling and pole classes, other conditions being equal. This observation is verified by the limited data. The fires also discriminated against Douglas fir and western larch, wherever such occurred in mixture with the ponderosa pines.

With respect to effects on larger trees occasional trees that were severely scorched have subsequently died of beetle attacks. Other occasional trees have burned down. In such instances, it is observed, the tree was usually very defective. No cruise data has been collected.

It is obvious that the fire hazard has been greatly reduced through

the elimination of the greatest portion of the slash, snag and windfall remains and heavy needle and litter mat on the forest floor. Fire scorched saplings and poles are hazardous during the first two years, but in the writer's opinion such hazard is more than offset by the above benefits. After the first two years most of the scorched needles drop off and by the third and fourth years the dead trees start falling over from rotting at the ground line.

Subsequent to the burning numerous ponderosa pine seedlings developed in the holes in the reproduction stands, where there are ash beds of burned up windfalls, and about the bases of large trees where the dense needle mat was consumed. On the plots burned during the fall of 1942 subsequent heavy trampling by cattle and horses killed large numbers of these seedlings, but many still survive.

Large numbers of cattle and horses congregated on these plots during the summer seasons of 1943 and 1944. On two of the plots, in the near vicinity of a shallow lake, the situation was particularly aggravated by the unauthorized action of a stockman, who dumped salt blocks about over the burned areas. The nearness of the lake and the salt impregnated ground still attract large numbers of stock.

During the summer of 1944 the Oregon pine engraver beetle, (Ips oregoni (Eich)), killed large numbers of saplings and poles on the recently cut-over portions of the Kartar unit. This epidemic appeared to have no connection with the burning, since trees on burned areas and on unburned areas miles away were attacked indiscriminately. Aside from this sporadic outbreak no insect activity of epidemic proportions has been observed.

COSTS

The average cost per acre of burning the five plots in 1942 amounted to $1.22. This cost was high because of considerable trucking expense involved in extra moving of the tractor and plow unit. While the burning was in progress the unit was returned to Colville Agency at Nespelem, a distance of 15 to 20 miles, on two separate occasions. Tractor expense was charged at the rate of $1.80 per hour while operating and 90 cents per hour while on standby. These charges may be unnecessarily high for such a small tractor.

The spot burning of slash, the writer believes, will give a more accurate picture of the costs involved in this type of burning. Such burning was conducted at an average cost per acre of 60 cents.

CONCLUSIONS AND DISCUSSION

Thinning of sapling and pole stands of ponderosa pine will prove successful if volume and quality growth can be accelerated and improved thereby. As has been indicated, too short a period of time has elapsed to prove anything in such respect from the tests herein described. Studies of thinnings caused by wild fires, however, make it appear reasonably certain that such success will be attained. On a burn that occurred in 1914 in a thick reproduction stand near Nespelem 7/ it has been found that the average tree in fire thinned 40 year age class poles is 7.4 inches D.O.B. at one foot above ground level and 32.2 feet in total height. Stocking in such patches averages 1100 trees per acre. On unburned areas immediately adjacent the average tree, in the same age class, is but 1.7 inches D.O.B. and 12.3 feet in total height, while stocking averages 14800 trees per acre.

The tests have proven that ponderosa pine reproduction stands can be thinned by controlled fire and that the fire hazard is greatly reduced through the elimination of a major portion of the fuel on the forest floor and in the snags and windfalls.

It is regretted that it has not been possible to gather more data from the tests conducted on the Colville Reservation. As has been explained it has been impossible for our small staff of foresters to conduct such research because of the press of other work. It is the writer's belief that similar tests and research should be conducted on a much wider scale, under varying conditions on various other portions of the ponderosa pine forest. To his knowledge there is a scarcity of factual information in the ponderosa pine region concerning the effects on vegetation and on plant successions resulting from total exclusion of fire and from application of fire in different intensities at varying intervals. It also appears that there has been an extreme scarcity of information concerning the technique of applying controlled fire.

In the southern pine region, where fire has also been of primary importance, these problems have been studied intensively. Garren, in summarizing factual information concerning the effects of fire on vegetation of the southeastern United States 2/ concludes that the longleaf pine forest probably originated as a result of fire and that frequent winter fires, in proper ratio to fire-free years, appear to be essential to the maintenance and perpetuation of longleaf pine. He also indicated that seedlings on areas winter-burned at intervals of three years may show twice as much growth as those not exposed to fire. Lemon, in discussing prescribed burn-

ing in relation to grazing in the longleaf-slash pine type 3/, concludes that such burning may also be beneficial in fire hazard reduction. Chapman, in his study of the management of loblolly pine in Arkansas and Louisiana 1/, concluded that fires at intervals of 8 to 10 years are essential for the maintenance of loblolly pine as a component of the mixed forest. Is it not possible that it may eventually be determined that somewhat similar periodic application of controlled fire will prove necessary in the management of ponderosa pine forests?

In conclusion a note of warning must be sounded. Though controlled fire may prove helpful it must always be remembered that it is an extremely powerful and treacherous tool. In conducting the Colville tests we have been fortunate in having men who are intensely interested and who have had considerable experience in handling fires. Most of the loggers employed on the work have also been interested and cooperative when our purposes and methods have been explained. A few of them, however, have been resentful at being assigned to the work and have failed to cooperate. It has been these men who have caused most of our troubles. We agree with Chapman's statement 1/ to the effect that: "The use of controlled fire demands the same character of experience, skill, and judgement as is required in any other class of technical operations which deal with complex and variable natural forces. It cannot be left to novices".

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